GNG 2101

Design Project User and Product Manual

PowerCycle

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
UPM	User Product Manual
PCB	Printed Circuit Board
BMG	Bicycle Mounted Generator
AC/DC	Alternating/Direct Current
COTS	Commercial Off-the-Shelf

Table 2. Glossary

Term	Definition
Brightness Knob	Black Knob that protrudes out of the electronics casing
Sensitivity Knob	Blue potentiometer that cannot be accessed without opening the casing

1 Introduction

This User and Product Manual (UPM) provides the information necessary for end users to effectively use the Bicycle Mounted Generator (BMG) and for prototype documentation. It contains detailed information on how our product works, how it can be operated, and how it can be improved. This includes all mechanical and electronic hardware components that went into the creation of our device. Also included are careful instructions on how to operate the device successfully with troubleshooting help instructions in case of any failures.

This document highlights the important parts of the prototyping process detailing our errors and testing. As well as some aspects of the device we would like to change or add, and any other improvements we would've made if it weren't for certain limitations and time constraints of the project.

2 Overview

There is a need for an efficient method of generating electricity that would power plant lights for a user's indoor plantation. In response to our client's demands for this product to double as a form of exercise, we designed the bike mounted generator prototype seen below. The user of this device can feel comfortable using their own bicycle and mount it onto the stand with special fittings and adjustable roller. As per the needs of the client's condition, the user is not subject to stressing upper joints and muscles while operating their bicycle.

What sets our model apart from current market alternatives is the efficiency of generation as a function of its production cost. Efficient market alternatives cost over thousands of dollars and still require an interface with a separate lighting system. Other cheaper alternatives are not capable of generating enough energy or simply do not allow for the user to do enjoyable physical activity while generating.

Figure 2.1. Bicycle mounted generator final prototype

The key feature of this product is the ability to adjust the stand and roller to the user's bicycle back tire diameter. Two wooden clamps allow for the attachment of modern through-axle tires, which uses the modified attachment and BMX pegs to secure the back wheel to the frame. Alternatively, if the user has an older nut threaded back tire, they may screw the BMX pegs directly. The roller is subsequently adjustable for different wheel diameters using two bolts to secure the arms.

A stand out feature of the electronics box is the use of a photoresistor to limit and save electricity when lighting is already sufficient, hence LEDs are not required. The output interface is also simplified and includes a plant LED strip for use.

The frame is made of wood, which is sturdy but also easy to manipulate and modify. The roller is a wooden rolling pin that rotates on a metal rod and is attached to a stepper motor generator. A control box is included which has an input wire that connects to the stepper motor. Inside is a control circuit with many special electronic parts, a battery pack and a battery protector. If the user wishes to modify the electronics enclosed inside the box, access is possible and maintenance can be conducted. Below is the high-level diagram that summarizes the function of our product.

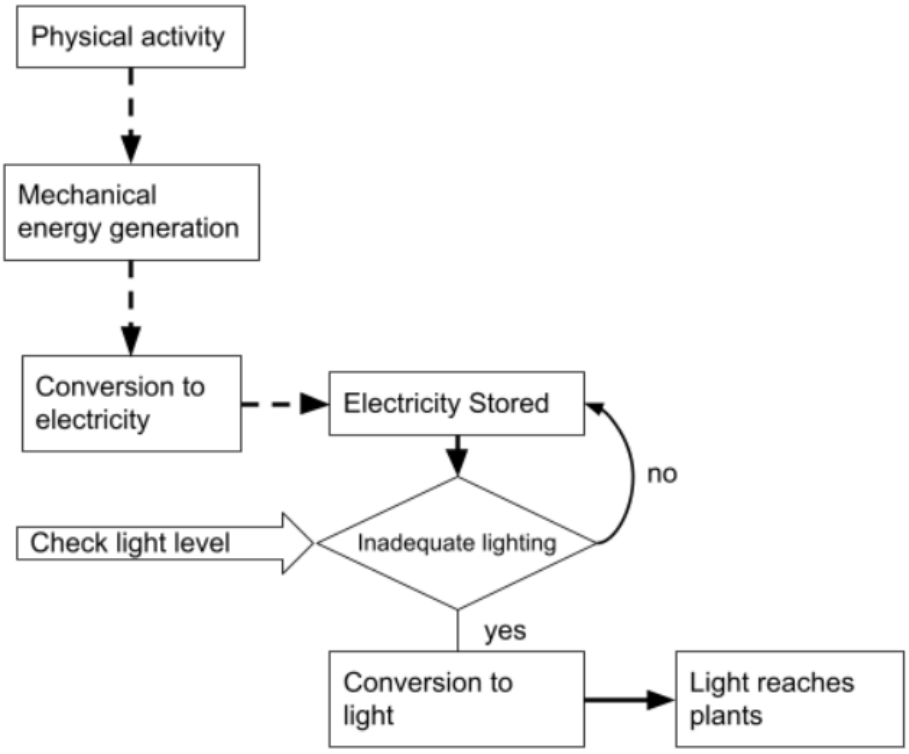

Figure 2.2. Block diagram of primary functions

2.1

2.2 Conventions

Throughout the document, any information regarding the electronics should be assumed in terms of AC signals. Since generation through the stepper motor is in alternating current, our circuit control board must input in AC and output in DC. Many mechanical components are also deemed to be “clamped” or “bolted” to the frame. These terms refer specifically to adjustable parts of the frame that deal with keeping the user’s bicycle locked in place while allowing the back wheel to spin with the roller. When referencing the “roller”, we’re referencing the entire roller assembly, which includes the arms, axle, rolling pin and motor.

The PowerCycle may be referred to as the “product” or the “prototype” within this document.

2.3 Cautions & Warnings

As the frame is primarily made of wood, despite having been well sanded, it is possible for slits of wood to protrude and cause splinters to the user handling wooden parts. Test rigidity of adjustments before using as some bolts or clamps may not be tight enough, which could cause damage to the product or the user. Although tested to be able to hold over 200 lbs, it is not recommended for morbidly obese users to operate the product.

If cycling for more than 1hrs double check that the circuitry isn’t hot. During some tests we’ve noticed an increase in temperature however this is not consistent and we are planning on rectifying them in the future iterations. Avoid using the device in particularly humid rooms, as moisture may damage the electronics enclosed inside the box.

3 Getting started

Below is a quick step by step guide which will let you know how to easily use our product

1) Plug the lights into the white wire protruding from electronics box

2) Plug the electronics box into the generator on the bike stand

3) Insert the bike onto the bike stand and tighten the clamps.
(See section 4 for further details)

4) Adjust the roller so that it is in firm contact with the rear wheel.
(See section 4 for further details)

5) Begin pedaling to produce power for the lights/battery.

3.1 Configuration Considerations

During the setup process it is important to calibrate the light sensor with the ambient light using the sensitivity knob that is accessible through the box. Place the stand in a position where it is close enough to the light source that you desire to power and make sure a wire is long enough to reach the control box. To calibrate the sensor, ensure the light level in the room is the desired amount that you wish the lights to be enabled at. Afterwards, use a flat screwdriver to adjust the sensitivity knob until the lights turn on.

3.2 User Access Considerations

This product makes use of the user's bicycle. Any person with access to a bicycle will be able to insert their bike into the stand and start generating power. The user must be capable of pedaling on a stationary bicycle for moderate periods of time.

3.3 Accessing/setting-up the System

Place the stand in an open space, enough to fit a bicycle and a set of lights. Position the electronics box in an area away from potentially harmful liquids or heat. Further operation instructions can be found in section 4.

3.4 System Organization & Navigation

The Frame:
The frame is where you mount the rear wheel of your bicycle. The bicycle is mounted to the frame using a clamping system.

The Generator:
The generator consists of the rolling cylinder in front of the frame which is attached to the stepper motor that generates AC power.

The Control Box / Electronics box:
The control box consists of an input for the generator and an output to the lights. It contains the battery and the battery management system. It also contains the ambient light adaptive mechanism.

3.5 Exiting the System

In order to safely put away the generator follow the following steps:

1) Disconnect the battery from within the control box
2) Disconnect the lights from the control box
3) Disconnect the generator
4) Remove the wheel from the mount
5) Store in a dry environment at room temperature

4 Using the System

The following subsections provide detailed, step-by-step instructions on how to use the various functions or features of the bike mounted generator.

4.1 Mounting a bicycle to the stand

The stand assembly allows for the user to attach the rear wheel of their bicycle onto the wooden trainer. This is done to keep the bicycle from moving and keeps it steady when stationary. To attach the bicycle to the stand, first take conscience as to whether the back wheel of your bicycle is a through-axle or traditional bolt assembly.

Figure 4.1. This is a through-axle assembly

Figure 4.2. This is a traditional bolt axle assembly

4.1 A

If the bicycle uses a traditional bolt assembly, use a wrench to unscrew the bolts on the bicycle's back wheel and screw on the BMX pegs onto the axle bolts. Use pliers to tighten the pegs. Place the bicycle's back wheel with the attached pegs onto the pillars of the stand. Align the BMX pegs with the "U" slots of the pillars. The wheel should now look like the below picture.

Figure 4.3. Back wheel of bicycle with attached BMX pegs slotted into stand pillars

If the bicycle is unable to move and is not tipping over, congratulations. The assembly is complete.

4.1 B

If your bicycle has a through-axle assembly, first remove the existing through-axle adapter from your back wheel. Consult your bicycle's user manual if you're not familiar with doing this. Next, you want to use the included "Kinetic Rear Skewer" trainer adapter.

Figure 4.4. The included and aforementioned Kinetic Rear Skewer trainer adapter

Similarly to removing the stock bicycle through-axle, unscrew the adapter's smaller cap and remove one spring. Insert the adapter axle into the back wheel's axle, put the removed spring back onto the axle and screw the cap back on. Tighten enough to lock the wheel axle in place. The new assembly should look like the picture below.

Figure 4.5. Assembled adapter

See the following tutorial on how to install the Kinetic Skewer if needed : https://youtu.be/WAvId6t9tKo

On each side of the adapter, insert the reversed BMX pegs, green cloth in, and position the loose peg in the stand's pillar holes. Ensure that the right peg (facing the front of the bicycle) is the stationary one. Align a bolt with the wooden clamp and the right BMX peg, screw the bolt until the assembly is sturdy. If the bicycle is unable to move and is not tipping over, congratulations. The assembly is complete and should look like the below image.

Figure 4.6. Assembled back wheel of bicycle with through-axle

4.1.1 Adjusting the roller

The roller arms can be slid back and forth to allow for adjustment of its position in relation to the mounted bicycle wheel's diameter. To achieve this, use a regular wrench or a socket wrench and a flathead screwdriver to remove the two bolts holding the roller's arms onto the pillars of the stand.

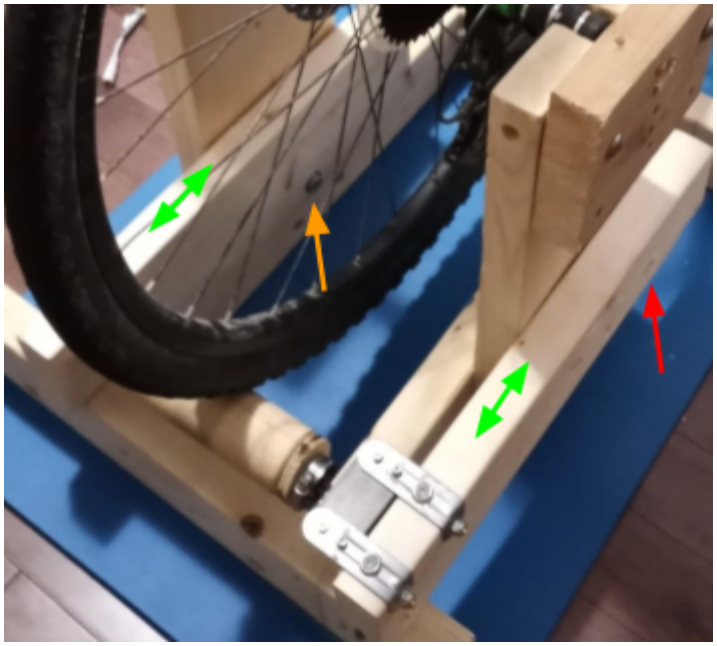

Figure 4.7. Roller adjustability

Orange arrow : unscrew bolt with wrench

Red arrow : hold using flathead screwdriver

Green arrow : slide arm and align hole with pillar, adjust based on back wheel diameter

Once the roller is positioned and the rolling pin is making contact with the back wheel, re-screw the bolt and tighten it after having aligned the bolt with the desired hole on the arm and the hole in the pillar. Make sure the assembly is sturdy and test the rolling pin rotation with the wheel making contact to ensure that the assembly is solid enough to begin using.

5 Troubleshooting & Support

5.1 Error Messages or Behaviors

Loud noise coming from the device is normal behavior. Due to uneven surfaces and the use of wooden parts, the product may slightly vibrate, producing noise. The roller axle may also appear to be uneven, which should not be cause for immediate concern as the product still functions with a slightly uneven axis. The motor will also generate noise, which indicates that the generation of electricity is working properly.

The roller that makes contact with the motor and the back wheel may become detached during use. If this happens, the roller can simply be reattached to the motor and rod on the back of the stand.

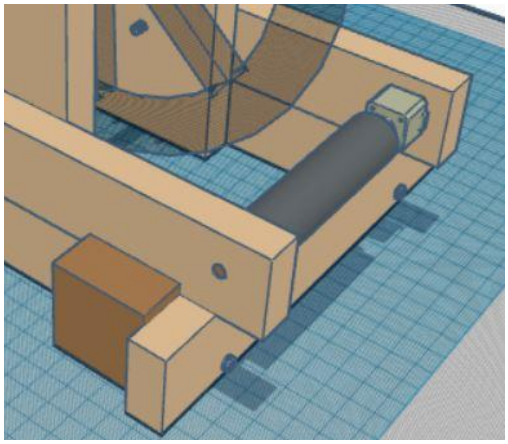

Figure 5.1. Roller assembly

The device failing to turn on when the ambient light level is low may be a result of an improperly calibrated sensor. To recalibrate it, open the casing to find a blue dial with a white knob. Make sure the ambient light is the desired turn-on brightness, then adjust the dial until the light turns on.

5.2 Special Considerations

If your bicycle wheel diameter is of abnormal or non-standard size, please contact us through the support coordinates below.

5.3 Maintenance

Batteries inside the control box should be unplugged when not in use.

5.4 Support

If further assistance is needed, you may contact the following correspondences:

Mechanical related issues:
Adam Ottaway: aotta060@uottawa.ca
Louis Marleau: lmarl090@uottawa.ca

Electronic related issues:
Darren Rahnemoon: krahn020@uottawa.ca
Mark Bacus: gbacu064@uottawa.ca

6 Product Documentation

6.1 Subsystems

6.1.1 Rear Wheel Mount

This part of the prototype makes up the majority of its volume and has multiple purposes. It has a slot designated for the adaptor interface which holds the rear wheel of your bicycle in place. It also holds the adjustable arm that can slide to best fit the contact between the back tire of your bicycle and the roller in order to spin the generator. A clamp system keeps the tire in place if using a through-axle wheel and a series of measured holes with simple bolt fasteners keep the roller arms in the correct slots.

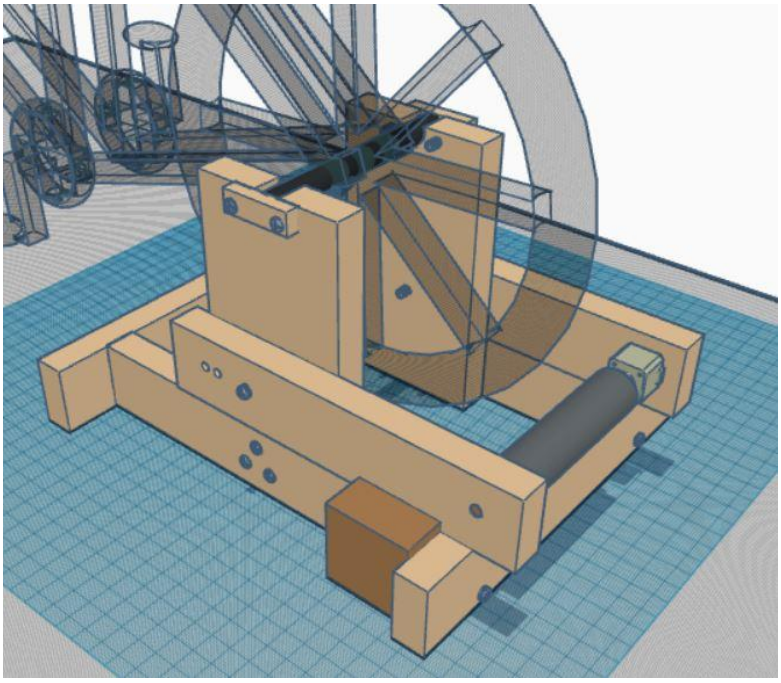

Figure 6.1. Bike trainer portion of the human powered generator

6.1.2 Electronics Box

The electronics box (depicted in figure 6.1 as the dark brown box) houses the batteries and control circuit needed for the generation to convert and redirect properly.

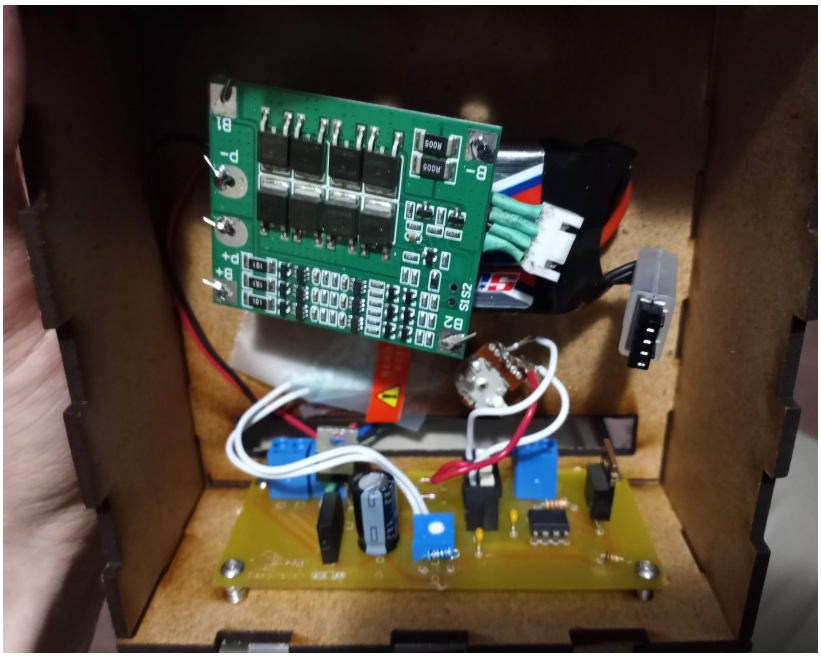

Figure 6.2. Circuitry inside the control box

6.2 BOM (Bill of Materials)

Below is the complete list of materials used in the production of the final prototype. Taxes included and free shipping through amazon prime. Not included are electronic testing / measuring devices and hardware power tools.

Table 6.1 : Bill of Materials

Product	Description	Link	Unit Price	Taxes	Items needed	Total before taxes	Shipping	Total after shipping
Stepper Motor/Generator	Power generation (Fasteners & mount included)	Link	$17.99	$2.34	1	$17.99	$0.00	$20.33
LED strip	Red & Blue LED strips	Link	$5.00	$0.00	2	$10.00	$0.00	$10.00
2in x 4in x 6ft Wood	Lumber	(Link)	$8.98	$1.17	3	$26.94	$0.00	$30.44
VT90N1	Photoresistor	Link	$0.95	$0.12	1	$0.95	$20.00	$21.07
1N4148	Diode	Link	$0.13	$0.02	2	$0.26	$0.00	$0.29
16YXJ1000MT810X16	1mF Capacitor	Link	$0.60	$0.08	1	$0.60	$0.00	$0.68
1825970000	3-Terminal Connector	Link	$1.90	$0.25	1	$1.90	$0.00	$2.15
OSTTA020161	2-Terminal Connectors	Link	$1.48	$0.19	3	$4.44	$0.00	$5.02
CL05A104KP5NNNC	100nF Capacitor	Link	$0.33	$0.04	2	$0.66	$0.00	$0.75
CRG0402F10K	10k Resistor	Link	$0.13	$0.02	1	$0.13	$0.00	$0.14
IRF520NPBF	N-Channel MOSFET	Link	$1.44	$0.19	1	$1.44	$0.00	$1.63
KBP206G	Bridge Rectifier	Link	$0.84	$0.11	1	$0.84	$0.00	$0.95
NE555P	555 Timer IC	Link	$0.59	$0.08	1	$0.59	$0.00	$0.67
RNCP0805FTD1K00	1k Resistor	Link	$0.15	$0.02	2	$0.30	$0.00	$0.34
TP0610K-T1-E3	P-Channel MOSFET	Link	$1.28	$0.17	1	$1.28	$0.00	$1.45
RC0201FR-07100KL	Potentiometer	Link	$2.36	$0.31	1	$2.36	$0.00	$2.67
P120KGP-F20	Potentiometer	Link	$1.06	$0.14	1	$1.06	$0.00	$1.20

BR100K								
FTVOGUE Battery Protection Board	BMS	Link	$9.43	$1.23	1	$9.43	$0.00	$10.66
Wires	Jumper Wires	Link	$0.10	$0.01	20	$2.00		$2.26
Printed PCB	Circuit board fabricated at makerspace	Makerspace	$0.00	$0.00	1	$0.00	$0.00	$0.00
3S LiPo battery	Lithium-polymer battery	Link	$23.99	$3.12	1	$23.99	$0.00	$27.11
BMX pegs	For bicycle wheel interfacing	Link	$11.99	$1.56	1	$11.99	$0.00	$13.55
Kinetic Rear Skewer	Through-axle trainer for rear wheel	Link	$13.99	$1.82	1	$13.99	$0.00	$15.81
8x3in wood screws	Stand screws	Link	$0.07	$0.01	8	$0.56	$0.00	$0.63
3/8 x 3 1/2 in bolts	Stand fastener	Link	$0.61	$0.08	13	$7.93	$0.00	$8.96
3/8in Slot Drive Nuts	Stand fastener	Link	$1.71	$0.22	2	$3.42	$0.00	$3.86
3/8in Nuts	Stand fastener	Link	$0.23	$0.03	6	$1.38	$0.00	$1.56
Washers	Stand fastener	Link	$0.17	$0.02	12	$2.04	$0.00	$2.31
MDF material	Box material	Makerspace	$2.50	$0.00	1	$0.00	$0.00	$2.50
							Total	$188.97

6.2.1 Equipment list

- LPK S104 ProtoMat Circuit Board Plotter
- Soldering Iron
- ⅜ inch wrench
- Circular saw

- Palm sander
- Flathead Screwdriver
- Power drill
- Stationary and portable clamps
- Drill press
- Drill bits
- Assorted measuring tools

6.3 Instructions

6.3.1.1 Trainer

The bike trainer should be constructed out of construction lumber and have 11 inches of clearance to accommodate the specialized through axle. The trainer needs to have enough surface area at the base to make sure that the bike is solid while pedalling. The base should be at least 20 inches wide and 23 inches long to achieve this. The lumber should be fastened together using hex bolts, washers and nuts, however other types of sturdy fasteners are acceptable. For reference image, see figure 6.1.

Once the trainer portion has been built, next is the arm that will be attached to the roller. This arm should also be fastened to the vertical legs in the stand using bolts. There should also be a slit in the arms to allow for horizontal movement of the arms. This will allow the position of the roller to be adjusted as needed. The roller itself is made up of a wooden rolling pin, a metal rod, a wooden handle, and a special assembly for the motor attachment seen below.

Figure 6.3.1.1. Motor attachment assembly

Using a round piece of plywood and an old radio knob, we could attach the motor axle to the piece of wood and screw it into the base side of the rolling pin. A pipe clamp was added for extra structural integrity. A hole is bored onto the opposite side of the motor and the rolling pin handle must be cut to length. Secure the handle side with an L bracket to prevent the handle from sliding out of the hole. On the motor arm of the assembly, use two smaller L brackets and mount the motor using fasteners and wood screws. For extra stability, maintain the metal rod's length and cut it to be the length of the roller, plus ¼ inch. A hole is then symmetrically bored into the opposite side of the piece of plywood. The final assembly should look like the figure below.

Figure 6.3.1.2. Complete roller assembly

Finally the clamps need to be attached to the trainer. The clamps consist of BMX pegs bolted firmly to a piece of 2X4, that when tightened to the stand using bolts will clamp onto the specialized axel on the rear wheel. One side of the clamp should be fixed firmly using screws or bolts, while the other needs to be free to move horizontally in order to firmly clamp the rear wheel axle. This should be done using blots as well as threaded inserts. The threaded inserts are to be inserted into the frame so that the bolts in the clamp section can be tightened, thus tightening the clamps.

For a visual representation of what the prototype should look like, refer to figure 6.1. and the below final assembly picture.

Figure 6.3.1.3. Final assembly

6.3.1.2 Electronics

Gerber files should be imported into the LKPF Circuitpro program and printed using default settings, with the exception of excluding pockets and rubbing out both top and bottom sides of the PCB. If a board plotter is unavailable, third-party manufacturers are acceptable. PCB assembly should be constructed in reference to the schematic and silkscreen labels on the board.

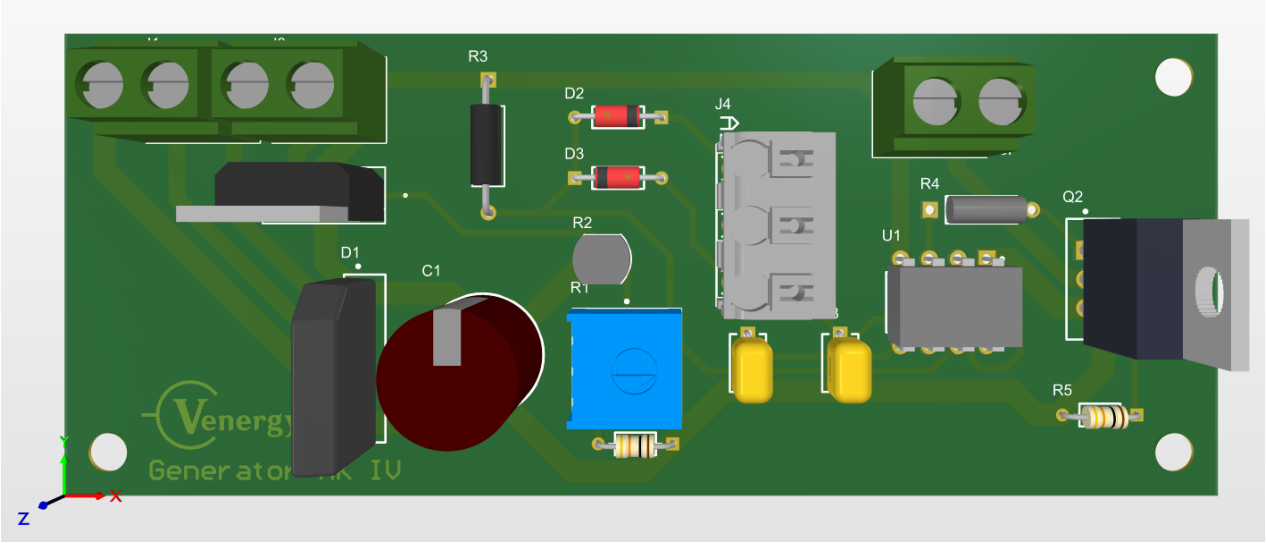

Figure 6.3. 3D Model the assembled board

It should be noted that photoresistor R2 is an exception to this, as wires approximately 3-4” in length should be soldered from its pins to the appropriate pads on the board to allow for placement of the sensor (stranded wire is preferable for this application.) In a similar fashion, the large potentiometer should be soldered to 3-4” long (preferably stranded) wires. The wipe is then to be inserted into the middle slot of the three-position connector, with the ground and power pins being inserted separately into the remaining slots. The connection diagram for the generator, battery and output lights are as follows.

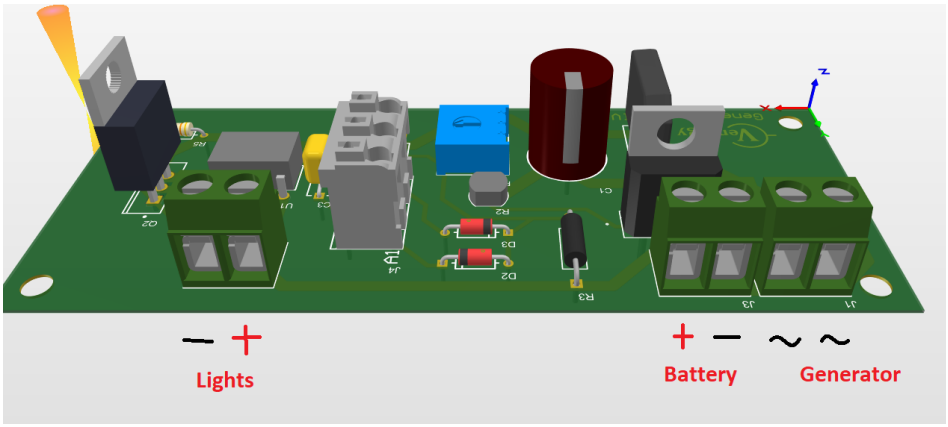

Figure 6.4. Polarities of input and output

The selected generator uses two coils. One contact from the first coil should be sorted to another contact on the second coil. In the following example, contact A should be soldered to contact B, and contact C should be soldered to contact D. These two sets of wires can then be plugged in the generator terminal block.

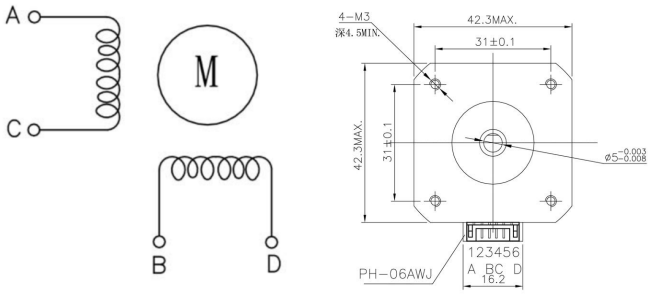

Figure 6.5. Stepper motor diagrams

Once complete, the board should be mounted inside of the electronics box, using M3 screws and spacers as necessary to keep the board from coming in contact with the casing.

6.4 Testing & Validation

6.4.1 Electronics

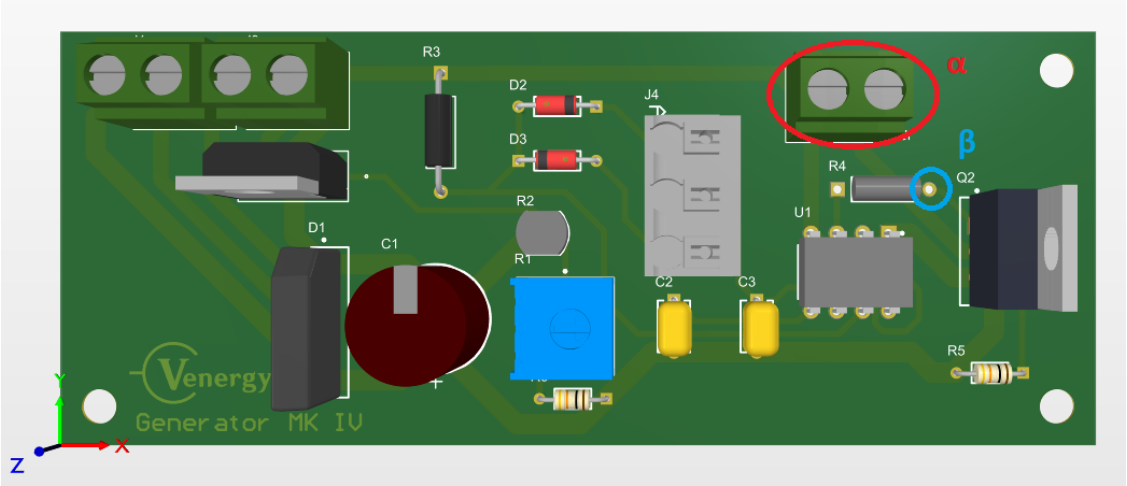

Figure 6.6. Diagram of the test points on the board

The sensitivity knob is used to set the sensitivity of the photoresistor and control at what light level the lights will be enabled. Adjust the internal blue potentiometer and apply varying levels of ambient light to the room to test functionality of the sensor. When 12 VDC is applied to generator input terminals, approximately 10VDC should be measured at test point α. When the ambient light is low enough to enable the device and the brightness knob is adjusted, the DC output voltage as measured across point α should change, furthermore, the waveform as measured from test point β in reference to ground should display as a PWM waveform with varying duty cycles.

6.4.2 Rear Wheel Mount

Tests showed that the stand was able to support over 200 lbs without any signs of structural stress. The frame is very solid and does not tip over, as from the results of extensive trials and tests.

Figure 6.7. Person using the mount

Through many tests with the through-axle interface and roller assembly included, the entire final prototype proved to be functional and no structural damage was observed. Slight warping of the right roller arm was identified as a result of overtightening the fastener bolt.

Rubber markings were also identified on the rolling pin surface as a result of friction between the back wheel and the roller. The device is particularly loud due to partially uneven surfaces and the motor itself.

7 Conclusions and Recommendations for Future Work

Over the course of developing this product, we learned the importance of developing a full detailed design as soon as possible, instead of building prototypes before reviewing our work.

Certain technical improvements can also be made. This includes replacing the rear-wheel-mount with a more robust structure, such as a modified COTS bike trainer. Furthermore, the circuitry should be improved to more efficiently rectify the two-phase output of the stepper motor by rectifying each phase separately.

8 Bibliography

Image references:

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APPENDICES

9 APPENDIX I: Design Files

Located below are the links to the project's files. Circuit diagrams and other miscellaneous project files can be found in the makerrepo repository.

Table 3. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
CAD model	https://www.tinkercad.com/things/e53nGO8KBo8-human-powered-lights	4/10/2022
MakerRepo	Venergy D11 | MakerRepo (makerepo.com)	4/10/2022